

Restoration and Management of Bald Eagles on Santa Catalina Island, California, 2002

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INTRODUCTION

In 1980, the United States Fish and Wildlife Service (USFWS) and the Institute for Wildlife Studies (IWS) initiated a program to reintroduce bald eagles (*Haliaeetus leucocephalus*) to Santa Catalina Island, California (hereafter Catalina Island). Between 1980 and 1986, 33 eagles were released on the island from three different artificial nest or “hacking” platforms (Garcelon 1988). Many of these birds matured and formed breeding pairs on the island, but all the eggs produced broke in the nest. Concentrations of DDE in the remains of eggs removed from failed nests implicated this contaminant as the causal agent of the lack of productivity (Garcelon et al. 1989), as DDE levels had been found to be inversely correlated with eggshell thickness and productivity in bald eagles in previous studies (Wiemeyer et al. 1984). During 1991-93, IWS studied food habits of the released eagles and documented high levels of DDE in the tissues of certain prey items commonly consumed by these eagles (Garcelon 1997, Garcelon et al. 1997a,b).

Since 1989, the reintroduced population has been maintained through manipulations of eggs and chicks at each nest site and through additional hacking of birds (Table 1). Because of the high DDE concentrations in the eggs, this active program of manipulation and augmentation is the only way to maintain the Catalina Island bald eagle population at this time. In the egg manipulation process, artificial eggs are substituted for the structurally deficient eggs laid by the birds affected by DDE. The adult eagles continue to incubate the artificial eggs while the removed eggs are relocated and artificially incubated at the Avian Conservation Center (ACC) at the San Francisco Zoo. Chicks that hatch from these removed eggs, or those produced by captive adults at the ACC or by wild birds, are then placed in the nests containing artificial eggs. Adult eagles on Catalina Island have successfully reared 32 of 40 chicks that were either fostered into nests (38 chicks) or hatched from two of three healthy eggs that were placed into nests between 1989 and 2002 (Table 1). Two of these 40 birds were removed from the nest prior to fledging because of injuries, two died accidental deaths, one bird was killed by a red-tailed hawk (*Buteo jamaicensis*) four days after being fostered into the nest (Perkins et al. 1996), one chick was killed by the nesting female on the day the chick was fostered into the nest, one chick disappeared under unknown circumstances, and one chick died after two days in the nest of unknown causes (Table 1). Continued hacking activities have also resulted in the release of an additional 19 eagles since 1991 (16 chicks and a 1-year-old bird; Table 1).

Previous studies have documented an effect of high concentrations of organochlorine pesticides on the reproductive behavior of avian species (Peakall and Peakall 1973, Haegele and Hudson 1977, Tori and Peterle 1983). Behavioral abnormalities observed in captive and wild birds have included less aggressive nest defense (Fyfe et al. 1976), increase in the length of courtship behavior (Tori and Peterle 1983), and erratic incubation behavior (Peakall and Peakall 1973). Given the extremely high concentrations of DDE found in eggs of bald eagles and other tissues collected on Catalina Island (Garcelon 1997), it is important to determine if these eagles exhibit aberrant nesting behavior so that management practices can be modified to ensure maximum success.

Table 1. Summary of Bald Eagle egg and chick manipulations on Santa Catalina Island, 1989-2002.

	Year													
	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
# of Active Nests	1	2	2	3	3	2	3	3	2	3	4	3	4	4
# of Eggs Laid	2	2-3	3	5	5-6	3	5	5-6	6	7	8	7	8	8
# of Eggs Collected	1	1	3	5	4	3	5	4	5	6	6	4	7	7
# of Catalina Island Eggs Hatched ^a	0	0	1	2	0	0	0	0	1	1	1 ⁱ	2 ^j	0	2
# of Eggs Fostered Into Nests on Catalina Island	0	0	2 ^b	0	0	0	1	0	0	0	0	0	0	0
# of Chicks Fostered Into Nests on Catalina Island	1	0	0	3	2 ^c	2 ^d	1	5 ^e	1	4 ^g	3 ^h	4	5	7 ⁱ
# of Chicks Fledged From Nests on Catalina Island	1	0	2	3	1	1	1	2	1	3	2	4	5	6
# of Eagles Hacked Onto Catalina Island	0	0	2	0	2	0	2	5 ^f	0	4	2	0	4	0
# of Island-Produced Eagles Breeding on Island	0	0	0	0	0	0	0	0	1	1	2	1	2	2
# of Second Generation Eagles Fledged	0	0	0	0	0	0	0	0	1	0	0	0	0	0

^a Hatched by the Santa Cruz Predatory Research Group (1991) or San Francisco Zoo (1992-Present)

^b Both hatched.

^c One chick died of asphyxiation on plastic bag.

^d One chick died during severe storm.

^e One injured chick was euthanized, one injured chick was treated and placed on hack tower, and one chick was killed by a red-tailed hawk.

^f Includes a one-year-old rehabilitated eagle and an eaglet that was removed from a nest because of a leg injury.

^g One chick killed by nesting female upon return to the nest following fostering.

^h One chick disappeared from nest under unknown circumstances.

ⁱ Hacked by Ventana Wilderness Sanctuary in central California.

^j One chick died in nest from unknown causes.

The purpose of this project is to maintain the breeding bald eagles on Catalina Island in the interim between completion of the injury assessment studies and the full-scale environmental restoration program now being planned. This report summarizes the results of the egg and chick manipulations and subsequent monitoring for the nesting season of 2002. Our restoration and management objectives were to: (1) document the chronology of nesting for all breeding pairs on the island, (2) collect eggs from wild nests on Catalina Island for artificial incubation, (3) foster healthy chicks into active nests, (4) collect tissues (blood, prey items, non-hatching eggs and embryos) for analyses of contaminants, (5) quantify incubation behavior, (6) quantify the behavior of adults and chicks between the time of hatching and fledging, (7) identify food items and quantify the rate at which prey deliveries were made to the nest, (8) release additional eagles on the island by using artificial nest platforms, and (9) monitor movement and behavior of all chicks fledged from wild and artificial nests on the island.

STUDY AREA

Catalina Island is located 34 km south of Long Beach, California. The island is 34 km long, 0.8 to 13.0 km wide, and covers 194 km² (Fig. 1). Elevations range from sea level to 648 m. There is considerable topographic relief, with numerous steep-sided canyons incising the island. Mean annual temperatures range from 12 to 20° C near the coast, and yearly precipitation averages 31 cm (NOAA 1985).

Vegetation on Catalina Island has been described by Thorne (1967). Predominant habitat types include: oak woodland, dominated by scrub oak (*Quercus dumosa*) and Catalina cherry (*Prunus lyonii*); grassland, dominated by oats (*Avena* spp.); and coastal sage, dominated by sage (*Salvia apiana* and *S. mellifera*), low shrubs (*Rhus integrifolia* and *R. ovata*) and prickly-pear cactus (*Opuntia* spp.).

Nesting Territories

Four territories of nesting bald eagles have occurred on the island since 1984. Because the data collected during this study were associated with these territories, a description of their locations and attributes of the occupying adults are provided.

The West End territory is located 0.5 km from the northwest end of the island (Fig. 1), and was established in 1991. The territory was initially occupied by 2 adult eagles (1 M, 1 F), but a second female has assisted in breeding activities since 1992 (Garcelon et al. 1995, Phillips and Garcelon 1996, Sharpe and Dooley 2001). The nest is located on a rock pinnacle approximately 75 m above the water, and has been used since 1991. From 1991-93, the foraging area of the trio covered a linear distance of approximately 4.5 km. On the north side of the island the foraging area extended from the western tip of the island approximately 2 km to the east, and on the south side of the island extended 2.5 km to the southeast.

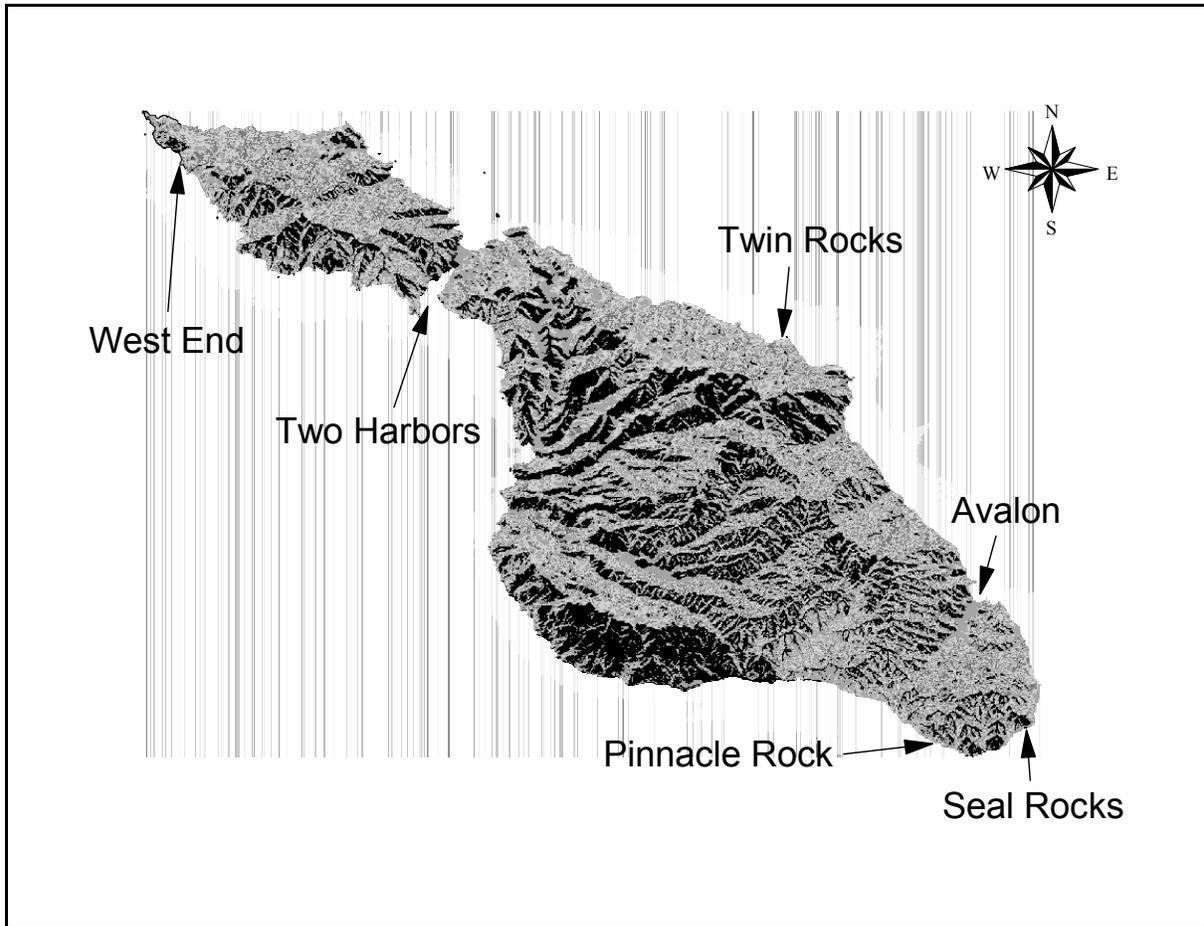


Figure 1. Active bald eagle territories and points of reference on Santa Catalina Island, CA.

The Pinnacle Rock territory is located 4.3 km southwest of the city of Avalon, extending from Silver Canyon to approximately 1 km east of the East End Light (Fig. 1). It was initially occupied in 1990 by a 5-year old female and a 4-year old male, and this territory has contained active nests each year since 1990. From 1991-93, the foraging area of the pair covered a linear distance of 3.5 km extending northwest from Binnacle Rock. The pair has remained intact and has used six different nests within this territory from 1990-2002 (Phillips and Garcelon 1996, Sharpe and Garcelon 1999, 2000).

The Twin Rocks territory is located 5 km northwest of the city of Avalon, extending from Torqua Springs to Little Gibraltar. This territory was initially occupied in 1984 and contained active nests in 1985, 1987 and 1989. The female remained in the territory until January 1995 when she was joined by a 4-year old male. The pair exhibited incubation behavior in 1996, but no eggs were found upon entry into the nest (Phillips and Garcelon 1996). Two eggs were removed from the nest in 1997, one of which successfully hatched, but the adults did not return to the nest following the egg switch (Sharpe and Garcelon 1998). In 1998, the original female was replaced by K-17, a bird released in 1986. A chick was fostered into the nest in 1998, but was killed by the female upon her arrival at

the nest approximately 8 hours later (Sharpe and Garcelon 1999). The pair accepted a single chick fostered into the nest in 1999, but the chick disappeared from the nest after approximately two weeks (Sharpe and Garcelon 2000). In both 2000 and 2001 the pair successfully fledged a chick fostered into the nest (Sharpe and Garcelon 2000, Sharpe and Dooley 2001).

The Seal Rocks territory is located 4.5 km SE of the city of Avalon (Fig. 1). The pair first nested in 1988, in a toyon (*Heteromoles arbutifolia*) in a canyon northwest of the East End light house. A second nest was built in 1990 in another toyon on a steep slope approximately 125 m above the ocean. From 1991-93, the foraging area of this pair covered a linear distance of approximately 3.0 km, extending from a point 0.3 km northeast of Seal Rocks to Church Rock located at the northwest end of the territory. This pair nested in 1988, 1990, and 1992. In 1993 eggs were broken in the nest prior to the attempted removal. The adult female from this territory died on 5 May 1993 from DDE contaminant poisoning (Garcelon and Thomas 1997). In 1995, another adult female laid two infertile eggs in the nest used in 1993. No male eagle was observed in the vicinity of her nest; therefore, the eggs were removed to prevent excessive stress associated with incubation by only one adult. The female abandoned the nest, and did not lay eggs again in 1995. No adults were seen in the territory in 1996 (Phillips and Garcelon 1996). In 1997, a new pair moved into the Seal Rocks territory (Sharpe and Garcelon 1998). The pair has extended its territory slightly to include areas around Avalon. There was no evidence of nesting in 1998. Prior to the 1999 breeding season the female was replaced by K-34, a zoo-raised bird that was hacked on Catalina in 1993. In 1999 the pair built a nest in a eucalyptus tree (*Eucalyptus* sp.) and laid one egg. Unfortunately, the nest blew out of the tree the following evening and there was no further nesting activity (Sharpe and Garcelon 2000). The pair did not attempt to nest in 2000, but successfully fledged a fostered chick in 2001 (Sharpe and Dooley 2001).

METHODS

Manipulations

Observations of adult eagles began in January this year to determine the location of breeding pairs and their respective nest sites. We documented the chronology of activity during the breeding season and located nest sites by observing areas of increased use by adult eagles and searching previously used nesting areas. When nest site locations were confirmed, we set up observation blinds to observe nests. From the blinds we monitored and quantified: 1) chronology of nesting, 2) behavior during incubation, 3) nestling and adult behavior during brood rearing, 4) taxon of prey delivered to the nest and 5) rates of prey deliveries. At the West End nest we had a video camera present (set up prior to breeding season) that allowed close observations of nesting activity.

We replaced eggs laid by nesting pairs with artificial eggs within 1-4 days of the date that eagles were confirmed incubating. We replaced the artificial eggs with healthy chicks (Fig. 2) after the adults had incubated approximately 30 days and returned to the nests when chicks were 8 weeks of age to equip them with federal and colored leg bands, wing markers, and a backpack-style

radio-transmitter. At this time we also collected a blood sample (~10 cc) for contaminant analyses and made morphological measurements to determine sex (Bortolotti 1984, Garcelon et al. 1985).

Incubation Behavior

We sampled incubation behavior at the Pinnacle Rock, Twin Rocks, Seal Rocks, and West End nests by monitoring them for approximately 6 hours/day for 2-3 days/week. The sex of adult birds was determined by the presence of patagial wing markers, leg bands, and size of adults. We recorded the exact times that adults laid on and stood from the eggs, probed the nest, or rolled the eggs. Additionally, descriptive notes were recorded to summarize general behavior and interaction of adults during the incubation period.



Figure 2. Two chicks being fostered into West End nest. Note artificial eggs in the nest.

We used the Mann-Whitney U-test (SYSTAT v. 9.0) to evaluate sex-specific differences in duration of complete incubation bouts. We defined complete incubation bouts as those in which we observed the incubating bird both start and end its attendance at the nest (i.e. switch with its mate).

Chick-Rearing and Nestling Behavior

We monitored behavior of chicks and adults at the Twin Rocks, Pinnacle Rock, Seal Rocks, and West End nests using interval sampling (Tacha et al. 1985) following the fostering of chicks. Postures and behaviors (See Appendix I) of chicks and any adults on the nest were recorded at 1-minute intervals, and sampling generally was conducted 2-3 days/week, up to 8 hours/day. Fog occasionally prevented or delayed sampling of behavior. We distinguished the roles of adult male and female eagles during the chick rearing period by comparing the proportion of time that each sex spent on the nest. We calculated the proportion of time that chicks spent in postures and behaviors for each day that birds were monitored. We evaluated the relationship of the age of the chicks to the proportion of time spent in each posture and behavior to document the onset of particular behaviors as chick development progressed. Changes in the frequency of occurrence of key postures and behaviors were plotted over time to demonstrate trends in behavior during the nestling period.

Prey Deliveries

Concurrent with interval sampling of behavior, we recorded date, time, and taxonomic information for all prey items delivered to the nests. We calculated mean rates of prey delivery for each nest as the number of items delivered divided by the amount of time the nests were observed.

Post-Fledging Behavior

We used radio-telemetry to locate and visually observe behavior of fledged eagles. We located and observed the fledged birds every 1-3 days during their first month of flight and recorded location, behavior, and interaction with other eagles.

Release of Additional Eagles

No additional bald eagles were released on the island this year through “hacking,” a procedure by which fledgling birds are reared on artificial nest towers and then released (see Garcelon 1988).

Collection of Tissue Samples

We collected 2-10.5 cc of blood for contaminant and DNA analyses during banding activities of juvenile bald eagles on Catalina Island. The ACC also collected samples of egg shells and embryos from the Catalina Island eggs transported to San Francisco for incubation. Egg contents were placed in chemically clean jars and frozen.

RESULTS

Manipulations and Nest Monitoring

Nests were located from February-April 2002 in four previously occupied territories: Twin Rocks, Pinnacle Rock, Seal Rocks, and West End (Fig.1).

Twin Rocks

The territory was used by the same pair that used it from 1998-2001. The male (K-33) was a bird that hatched from a Catalina egg in 1992 and the female (K-17) was a bird released at the Bulrush hacktower in 1984. In early February, the pair was seen working on the same nest that they used in 2001. The pair worked on the nest until 10 February, when they were observed exhibiting incubation behavior and one egg was confirmed to be in the nest. We entered the nest via helicopter on 14 February and removed two eggs. Both eggs were fertile and were artificially incubated at the ACC. One egg successfully hatched, but the bird developed a problem with its leg and was eventually euthanized after unsuccessful rehabilitation.

Two chicks produced by captive bald eagles at the ACC were fostered into the Twin Rocks nest on 27 March. The adults returned quickly and were observed brooding and feeding both chicks on 27 and 28 March. On 29 March the younger chick was seen dead in the nest. We did not attempt to retrieve the carcass so as not to further disturb nesting activity. We returned to the nest on 12 May to install leg bands, transmitter, and wingmarkers on the chick and to obtain a blood sample (Table 2). We continued monitoring the nest until the chick fledged on or about 30 May.

Table 2. Biographical data for bald eagle chicks successfully fostered into nests on Santa Catalina Island, California during 2001.

Federal Band	Color Band	Wing Marker	Date Fledged	Foster Nest	Status ^a	Comments
629-02790	5/P	K-23	5/23/02	Pinnacle Rock	Unknown	From captive pair at ACC. Left island around 17 July.
629-02791	5/E	K-22	5/29/02	Pinnacle Rock	Unknown	From captive pair at ACC. Left island around 17 July.
629-02792	6/C	K-21	5/30/02	Twin Rocks	Alive	From captive pair at ACC. Left island around 6 September.
629-02793	6/G	K-26	6/11/02	West End	Alive	From captive pair at ACC. Still on island. ^b
629-02794	6/D	K-27	6/14/02	West End	Unknown	Hatched from West End egg. Left island around 17 July.
629-02799	6/R	K-28	7/30/02	Seal Rocks	Alive	From captive pair at ACC. Left island around 27 September.

^a As of 11/15/02

^b Left island around 8/28 and returned around 10/23.

West End Territory

The West End trio of birds used the same nest that has been used since 1991. The male has lost his wing markers, but is believed to be K-77, a 21-year-old bird released from a hacktower in 1981. The original female (referred to as Female 1 hereafter) was not marked with patagial tags, but is believed to be a 16-year-old bird released at the Sweetwater hacktower in 1986. The

second female, which joined the original pair in 1992 (referred to as Female 2 hereafter), is a 16-year-old bird (patagial tag K-69) that was also released at the Sweetwater hacktower in 1986. Incubation behavior was first observed on 14 February and we replaced three eggs with artificial eggs on 18 February. All three eggs were fertile, but only one of the eggs hatched. Another egg was seen in the nest on 24 February, but we did not remove this egg and it broke within 2 weeks.

One ACC-produced chick and the chick that hatched from the West End egg were fostered into the West End nest on 31 March. On 18 May, we returned to the nest to install leg bands, transmitters, and wingmarkers on the chicks and to obtain blood samples (Table 2). We continued monitoring the nest until the chicks fledged between 11 and 14 June.

Pinnacle Rock

The Pinnacle Rock pair used the same nest as in 2001. The 16-year-old male (K-65) was hatched at the Bulrush tower in 1986. The female, who has lost her wing markers, is believed to be a 17-year-old bird hatched at the Bulrush tower in 1985. The birds were first seen at the nest on 20 January. On 22 February a single egg was seen in the nest and we removed the egg via helicopter on 23 February. The removed egg showed signs of development but it did not hatch.

On 27 March, we introduced two ACC-produced chicks into the nest, again using a helicopter. We entered the nest on 11 May to install leg bands, a transmitter, and wingmarkers on the chicks, and to sample blood (Fig. 3). Monitoring of this nest continued until the eaglets fledged between 23 and 30 May (Table 2).

Seal Rocks Territory

The Seal Rocks pair constructed a new nest on a rock ledge near Seal Rocks at the eastern tip of Catalina. The 9-year-old female (K-34) is from the captive ACC eagles and was hatched at the Bulrush tower in 1993. The 10-year-old male (K-25) hatched from an egg from the West End territory and was fostered into the Pinnacle Rock nest in 1992. The pair was observed working on the nest from 18 March until incubation was confirmed on 16 April. We removed one egg on 18 April, replacing it with two artificial eggs. The chick from this egg developed and partially hatched before dying.



Figure 3. Approaching Pinnacle Rock nest to band eagle chicks.

A single ACC-produced chick was fostered into the nest on 5 June. We returned to the nest on 13 July to install leg bands, a transmitter, and wingmarkers on the chick, and to sample blood. We continued to monitor the nest until the bird fledged on or about 30 July (Table 2).

Incubation Behavior

We monitored the incubation behavior at the Twin Rocks nest for 17 days between 11 February and 24 March, at the West End nest for 12 days between 18 February and 23 March, at the Pinnacle Rock nest for 15 days between 22 February and 26 March, and at the Seal Rocks nest for 6 days between 19 April and 16 May. Observations were reduced at the Seal Rocks nest because heat waves made it difficult or impossible to observe activity at the nest through a spotting scope.

We detected no difference in the length of incubation bouts between the Pinnacle Rock birds ($P = 0.28$), the Seal Rocks birds ($P = 0.18$), or the Twin Rocks birds ($P = 0.08$). There was a significant difference in the bout lengths among the West End birds ($P = 0.05$), primarily because Female 2 had shorter bout lengths than the other two adults present (Table 3). When all complete bouts were combined by territory (not including the West End), there was no significant difference in bout length between the three remaining territories ($P = 0.07$).

Table 3. Number (n), mean, and standard deviation (SD)(hrs:minutes) for adult eagles observed during incubation at the Pinnacle Rock, Seal Rocks, Twin Rocks, and West End nest on Santa Catalina Island, 2002.

Territory	Male			Female 1			Female 2 ^a		
	n	Mean	SD	n	Mean	SD	n	Mean	SD
Pinnacle Rock	14	1:49	1:06	15	1:20	0:41	.	.	.
Seal Rocks	5	0:57	0:24	5	1:42	0:52	.	.	.
Twin Rocks	3	2:58	0:24	4	1:46	0:46	.	.	.
West End	11	1:13	0:39	10	1:25	1:02	10	0:39	0:27

^a Female 2 was released from the same hacktower as the West End Female 1 in 1986.

Chick-Rearing and Fledgling Behavior

We made behavioral observations for 22 days at the Twin Rocks nest (28 March-21 May), 23 days at the Pinnacle Rock nest (27 March-28 May), 21 days at the West End nest (1 April-12 June), and 15 days at the Seal Rocks nest (10 June-1 August). Six of seven chicks fostered into nests this year successfully fledged.

Adult females spent a significantly greater portion of their time at nests than males at the Pinnacle Rock (71% vs. 42%, $P = 0.0001$), Twin Rocks (53% vs. 35%; $P = 0.0371$), and Seal Rocks nests (79% vs. 12%; $P = 0.0001$). At the West End nest there was no significant difference in the amount of time Female 1 and Female 2 spent at the nest (51% and 55%, respectively), but the male spent significantly less time at the nest (20%) than either female ($P \leq$

0.0005). There was also a significant negative relationship between time spent at the nest and the age of the chick(s) for all adults at the West End nest ($P \leq 0.0026$), and for the males at the Pinnacle Rock and Twin Rocks nests ($P \leq 0.0165$). There was no significant relationship for the Seal Rocks birds or the females at the Pinnacle Rock and Twin Rocks nests ($P > 0.05$; Fig. 4).

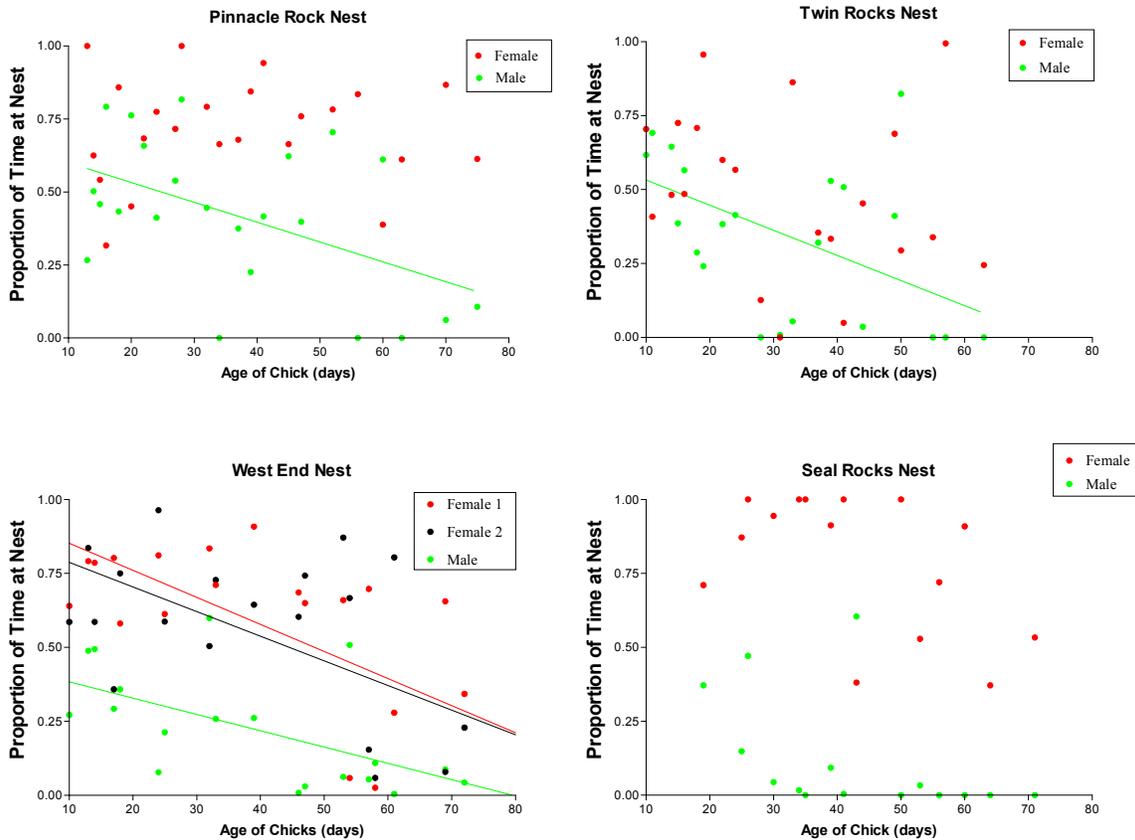


Figure 4. Proportion of time spent by adult bald eagles at the Twin Rocks, Pinnacle Rock, West End, and Seal Rocks nests during chick-rearing. At the West End nest, Female 1 is the original breeding female and Female 2 is a second female that later joined the original pair. The lines in the graphs are the best fit for the female (—), male (—), and Female 2 at the West End (—)

The proportion of time the chicks spent standing increased rapidly starting at an age of approximately 45 days at all four nests (Fig. 5). The chicks were observed feeding on their own as early as 15 days of age, but self-feeding did not increase substantially until they were about 45-50 days of age (Fig. 6)

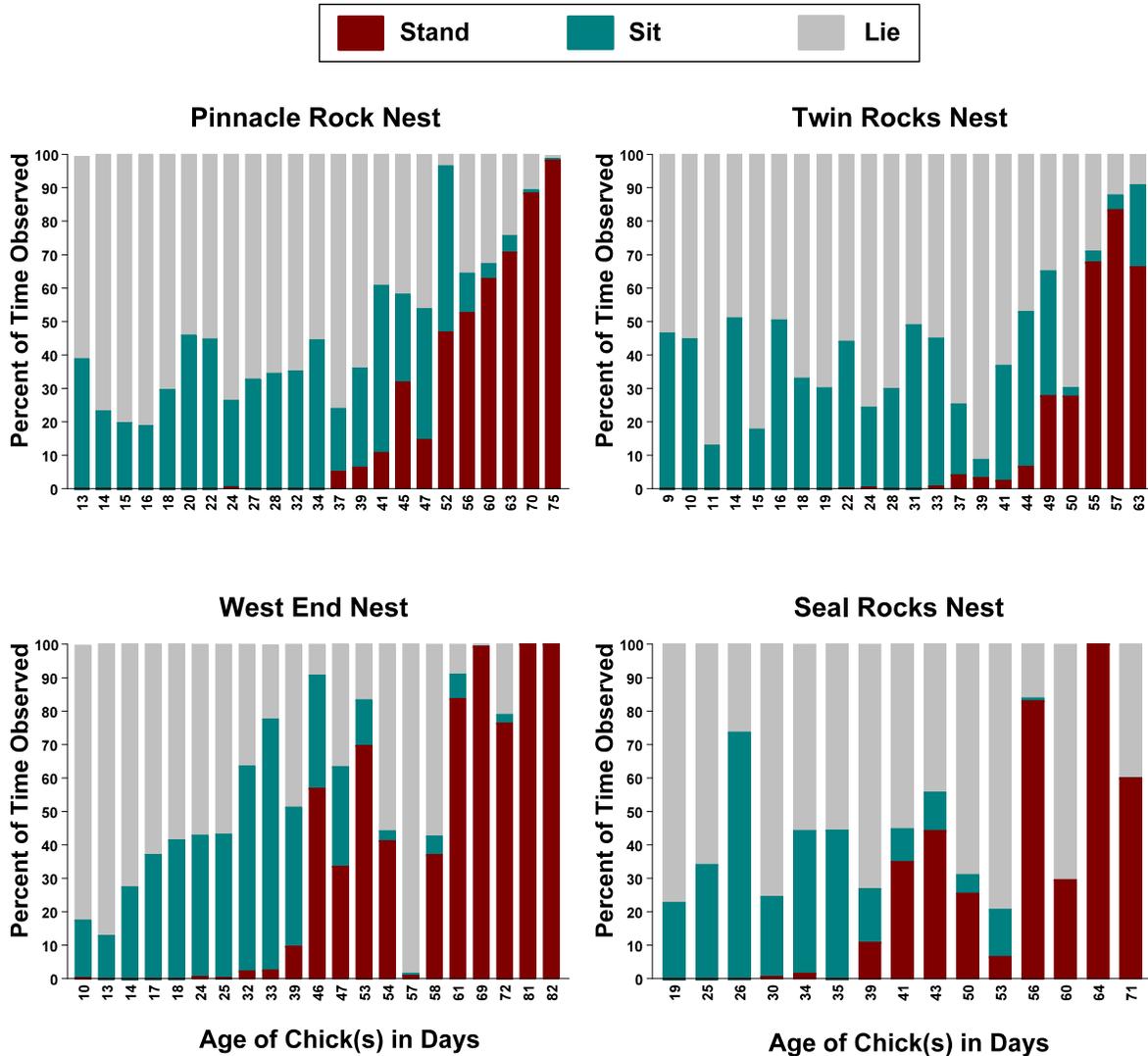


Figure 5. Percent of time that chicks spent in 3 different postures at the Pinnacle Rock, Twin Rocks, West End, and Seal Rocks nests, Santa Catalina Island, 2002.

Prey Deliveries

We observed 21 prey deliveries at the Twin Rocks nest during 101.3 hours of observations (0.21 items/hr), 27 prey deliveries at the Pinnacle Rock nest during 88.1 hours of observations (0.31 items/hr), 40 prey deliveries during 91.5 hours of observations at the West End nest (0.44 items/hr), and 5 prey deliveries during 46.4 hours of observations at the Seal Rocks nest (0.11 items/hr). At all the nests the males made more deliveries than the females (Fig. 7). We were able to identify prey items to Family or Genus for 14 of 22 deliveries (64%) at the Twin Rocks nest, 9 of 27 deliveries (33%) at the Pinnacle Rock nest, 17 of 40 deliveries (43%) at the West End nest, and 0 of 5 deliveries (0%) at the Seal Rocks nest (Table 4). The Class of the prey was

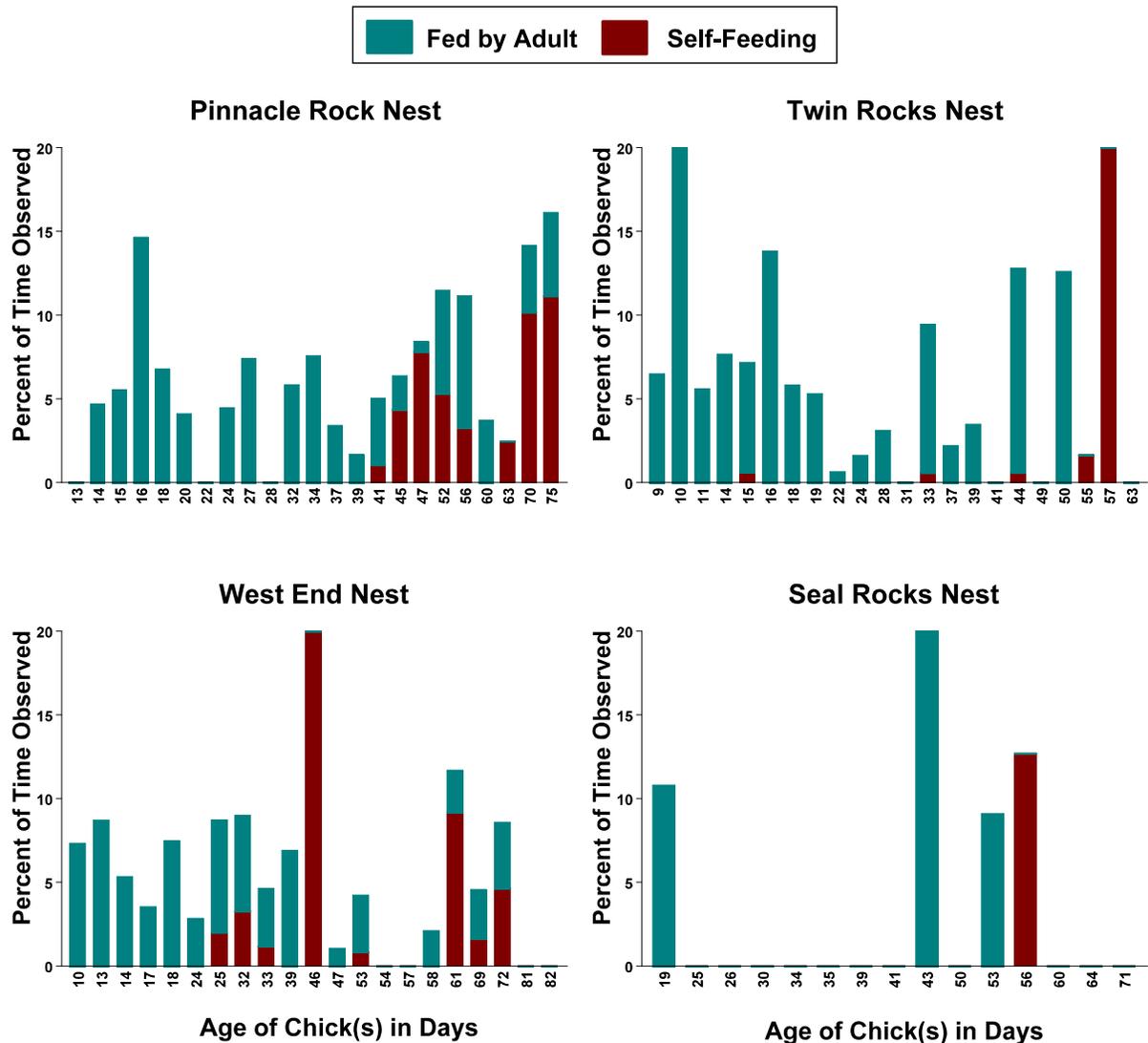


Figure 6. Percent of time that chicks were observed being fed by adults or self-feeding at the Pinnacle Rock, Twin Rocks, West End, and Seal Rocks nests, Santa Catalina Island, 2002.

determined for 22 of 22 deliveries (100%) at the Twin Rocks nest, 27 of 27 deliveries (100%) at the Pinnacle Rock nest, 37 of 40 deliveries (92.5%) at the West End nest, and 5 of 5 deliveries (100%) at the Seal Rocks nest (Table 4).

Post-Fledging Behavior

The Pinnacle Rock chicks (K-22 and K-23) fledged about one week apart (29 May and 23 May, respectively; Table 2). The signal from K-23 continually came from the hillside above the nest following fledging, but the bird was not actually seen again until 28 May, when it was perched on

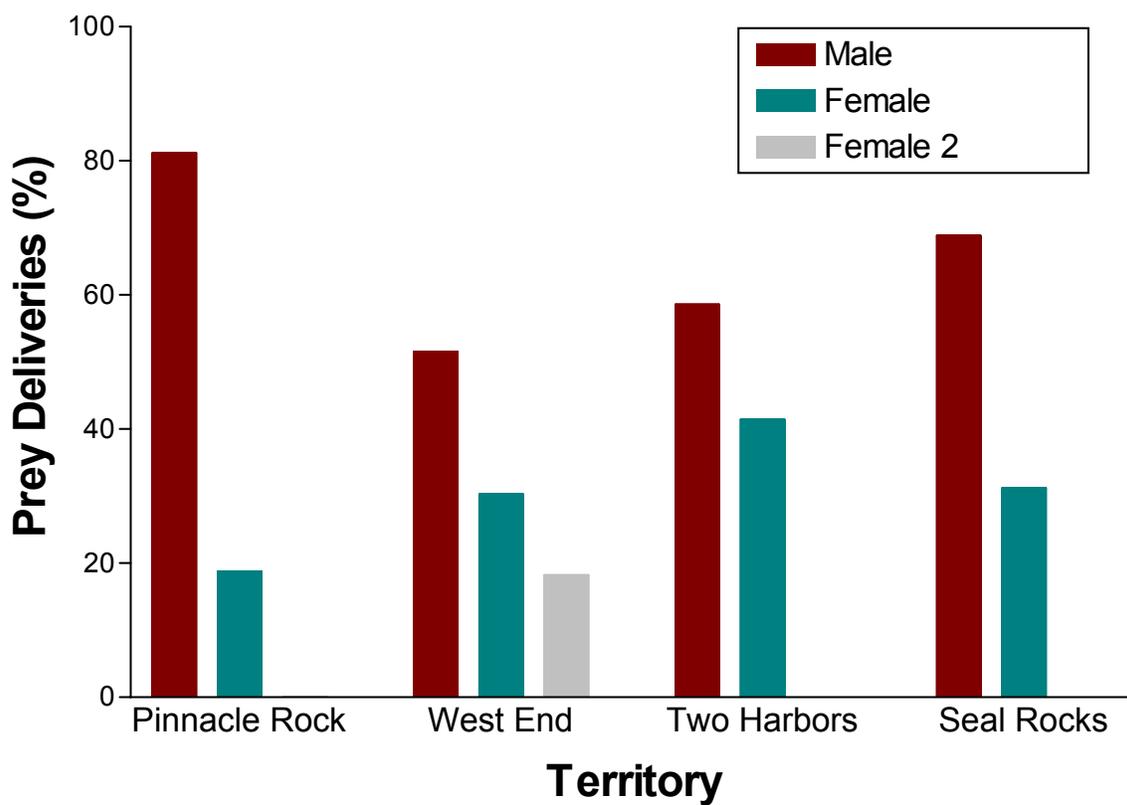


Figure 7. Percent of prey deliveries made by adults to nests in 4 different territories in 2003. Female 2 is a second female helper at the West End nest.

the hillside north of the nest. We repeatedly observed K-23 perched and flying near the nest and it was seen soaring above the Seal Rocks territory on 30 June. The last signal from this bird was on 16 July, near its nest. K-22 also remained near the nest until 30 June, when it was also soaring above Seal Rocks. On 7 July it was seen soaring/perching near the West End nest with the two fledglings from that nest. K-22 was also last seen near its own nest on 16 July.

The Twin Rocks chick (K-21) fledged on or about 30 May (Table 2). The bird remained in the vicinity of the nest until 23 August, when it was seen flying near the west end of Catalina Island. This bird was last confirmed on the island on 6 September, after which we assume the bird left the island. K-21 was reported in Klamath, CA on 23 October, perched with another young eagle along the Klamath River estuary.

The West End chicks (K-26 and K-27) fledged approximately 3 days apart (11 and 14 June, respectively; Table 2). K-26 remained in the vicinity of the nest until 26 August, at which time it was seen soaring near Avalon. We continued to get a signal from the bird on the island until 28 August, at which time it likely left the island. On 29 August, it was seen perched on the California condor cages at the Los Angeles Zoo. On 30 August, K-26 was back on Catalina

Table 4. Number and percent of food items delivered to the Pinnacle Rock, West End, Twin Rocks, and Seal Rocks nests during monitoring on Santa Catalina Island, California, 2002. Table includes prey that were present in the nest at beginning of observation periods.

Food Item	Prey deliveries							
	Pinnacle Rock		Seal Rocks		Twin Rocks		West End	
	n	% of Total	n	% of Total	n	% of Total	n	% of Total
FISH								
Unknown fish	17	63.0	5	100.0	6	28.6	20	50.0
Unknown herring (various spp.)	0	0.0	0	0.0	0	0.0	0	0.0
Northern anchovy (<i>Engraulis mordax</i>)	0	0.0	0	0.0	0	0.0	0	0.0
Pacific sardine (<i>Sardinops sagax</i>)	0	0.0	0	0.0	1	4.8	0	0.0
Bocaccio (<i>Sebastes paucispinis</i>)	0	0.0	0	0.0	4	19.0	1	2.5
Yelloweye rockfish (<i>Sebastes ruberrimus</i>)	1	3.7	0	0.0	0	0.0	1	2.5
Unknown rockfish (<i>Sebastes</i> spp.)	2	7.4	0	0.0	2	9.5	4	10.0
Aurora rockfish (<i>Sebastes aurora</i>)	1	3.7	0	0.0	0	0.0	0	0.0
Halfmoon (<i>Medialuna californiensis</i>)	2	7.4	0	0.0	1	4.8	1	2.5
White seabass (<i>Atractoscion nobilis</i>)	2	7.4	0	0.0	0	0.0	0	0.0
California Sheephead (<i>Semicossyphus pulcher</i>)	1	3.7	0	0.0	0	0.0	0	0.0
Rosy rockfish (<i>Sebastes rosaceus</i>)	0	0.0	0	0.0	0	0.0	1	2.5
Brown Rockfish (<i>Sebastes auriculatus</i>)	0	0.0	0	0.0	0	0.0	1	2.5
Kelp bass (<i>Paralabrax clathratus</i>)	0	0.0	0	0.0	1	4.8	0	0.0
Topsmelt (<i>Atherinops affinis</i>)	0	0.0	0	0.0	2	9.5	3	7.5
Unknown surfperch (various spp.)	0	0.0	0	0.0	0	0.0	1	2.5
Pacific mackerel (<i>Scomber japonicus</i>)	0	0.0	0	0.0	0	0.0	1	2.5
Catalina conger (<i>Gnathopis catalinensis</i>)	0	0.0	0	0.0	0	0.0	1	2.5
Garibaldi (<i>Hypsypops rubicundus</i>)	0	0.0	0	0.0	2	9.5	0	0.0
Fish Subtotal	26	96.3	5	100.0	19	90.5	35	87.5
BIRDS								
Unknown birds	1	3.7	0	0.0	0	0.0	0	0.0
Unknown gull (<i>Larus</i> sp.)	0	0.0	0	0.0	1	4.8	0	0.0
California gull (<i>Larus californicus</i>)	0	0.0	0	0.0	0	0.0	1	2.5

Table 4. Continued

Food Item	Prey deliveries							
	Pinnacle Rock		Seal Rocks		Twin Rocks		West End	
	n	% of Total	n	% of Total	n	% of Total	n	% of Total
<u>BIRDS (Cont.)</u>								
Xantus' murrelet (<i>Synthliboramphus hypoleucus</i>)	0	0.0	0	0.0	0	0.0	1	2.5
Birds Subtotal	1	3.7	0	0.0	1	4.8	2	5.0
<u>MAMMALS</u>								
Unknown mammal	0	0.0	0	0.0	1	4.8	0	0.0
Mammal Subtotal	0	0.0	0	0.0	1	4.8	0	0.0
<u>OTHER</u>								
Unknown	0	0.0	0	0.0	0	0.0	3	7.5
Other Subtotal	0	0.0	0	0.0	0	0.0	3	7.5
TOTAL FOOD ITEMS	27		5		21		40	

Island, but it left again on 2 September. K-26 was spotted along a road in Marina, CA on 17 September. Finally, on 23 October, the bird was again seen on Catalina Island. K-27, which was hatched from an egg removed from the West End nest, was first seen away from the nest area on 11 July, when it was observed soaring near Little Harbor. The bird was last seen near its nest on 16 July, and is assumed to have left the island soon after.

The Seal Rocks chick (K-28) fledged around 30 July (Table 2). The bird was first known to have left the Seal Rocks territory on 18 September, at which time its signal was near Two Harbors. K-28 was last known to be on the island on 27 September.

Additional Eagle Sightings

We have seen or had reports of sightings of eagles we released in previous years from both the mainland and Catalina Island. These reports are summarized below.

K-68 (FWS Band #629-39806), a captive-reared bird that was fostered into the West End nest in 1996, was reported near Dales, CA on 7 May.

K-80 (FWS Band # 629-39815), a captive-reared bird that was fostered into the West End nest in 1998, has remained on Catalina Island. On 31 October, it was observed feeding on a cormorant (*Phalacrocorax* sp.) north of Avalon.

K-81 (FWS Band # 629-39816), a captive-reared bird that was fostered into the West End nest in 1998, has remained on the island after returning in 2000.

K-82 (FWS Band # 629-39817), a bird that hatched from a West End egg and was fostered into the Pinnacle Rock nest in 1998, has remained on Catalina Island and has apparently paired with K-81. Both birds are regularly seen near Two Harbors and may begin breeding next season.

K-92 (FWS Band # 629-29496), a captive-reared bird that was released from the Bulrush hacktower in 1999, has remained on Catalina Island and the last confirmed sighting was on 28 June.

K-93 (FWS Band # 629-29497), a captive-reared bird that was released from the Bulrush hacktower in 1999, has remained on Catalina Island and can be seen almost everyday at Thompson Reservoir in Middle Canyon.

K-00 (FWS Band #629-39820), a captive-reared bird that was fostered into the Twin Rocks nest in 2000, was reported on San Clemente Island on 2 May. On 19 June we got a report that this bird had been snagged by fishermen north of Avalon on Catalina Island. The fishermen pulled close to the bird and cut the line near the lure. We searched for several days, but were unable to locate the bird.

K-01 (FWS Band # 629-29499), a captive-reared bird that was fostered into the Pinnacle Rock nest in 2000, was reported near McDoel, CA on 5 August.

K-02 (FWS Band # 629-29499), a captive-reared bird that was fostered into the West End nest in 2000, and which was last reported near Klamath Falls, OR on 15 January 2001, was seen on Catalina Island on 20 March and 6 April.

K-13 (FWS Band # 629-02783), a captive-reared bird that was fostered into the Pinnacle Rock nest in 2001, was observed at China Point on San Clemente Island on 16 March. The bird returned to Catalina Island by 11 April and stayed until at least 13 July. On 22 July it was reported near Summer Lake, Lake Co., OR.

K-16 (FWS Band # 629-02784), a captive-reared bird that was fostered into the Seal Rocks nest in 2001, was reportedly observed feeding on dead salmon on the Chetco River near Brookings, OR on 8 January.

K-18 (FWS Band # 629-02785), a captive-reared bird that was released from the Bulrush hacktower in 2001 has remained on Catalina Island and was last seen perched above a dead sea lion on 2 April.

K-19 (FWS Band # 629-02787), a captive-reared bird that was released from the Bulrush hacktower in 2001, left the island briefly in October 2001, but returned to and has remained on Catalina Island. It was last seen perched above a dead sea lion on 2 April.

K-20 (FWS Band # 629-02789), a captive-reared bird that was released from the Bulrush

hacktower in 2001, was seen on San Clemente Island on 29 and 30 January. This bird had moved to Lake Cachuma near Santa Barbara, CA by 5 February. It was last reported in San Benito Co., CA on 16 November.

Collection of Tissue Samples

We collected blood samples for chemical analyses from six juvenile bald eagles on Catalina Island this season. In addition, the ACC collected the egg contents and shells from eggs that were collected on Catalina Island and failed to hatch, as well as tissue samples from an eagle that hatched, but was later euthanized (Appendix II).

DISCUSSION

Artificial Nest Manipulation

As has been indicated in other studies of bald eagles (e.g., Anthony et al. 1994), we do not believe that continued research activities at the nest will negatively impact the nesting success of bald eagles on Catalina Island. Our results from this season indicate that the reproduction of bald eagles on Catalina Island continues to suffer from greatly reduced hatchability of eggs. We collected seven eggs this year, all of which were fertile, but of which only two eggs hatched (28.5% hatching rate). Since the egg removal phase of this project began in 1989, only 10 of 51 fertile eggs have hatched (19.6% hatching rate). This low hatching success and the fact that an additional egg broke in the West End nest following egg removal, further emphasize the need for active management of the population and clean-up of the contaminated environment. Failure to hatch may be a result of excessive water loss associated with abnormal eggshell structure (Risebrough 1993). The ACC is able to reduce water loss using a variety of techniques following the transport of the eggs to the Zoo, but the eggs have often lost a large amount of water prior to removal from the nest.

The egg and chick manipulations during 2002 were successful as we were successfully able to foster six eagles into a total of four nests on the island. Removal of eggs from bald eagle nests may cause abandonment of nests in some cases (Anthony et al. 1994), but because of our ability to access nests quickly bald eagles on Catalina Island rarely abandon nests following our manipulations. It also appears that both females at the West End nest likely laid eggs this year, as at least four eggs were laid in the nest.

We anticipate productivity at the Catalina Island eagle nests in 2003 to be similar to this year. There is a possibility that K-81 and K-82 may attempt to breed next year, because both birds have nearly complete adult plumage and have been seen together for nearly two years. We will begin searching for breeding activity in mid-January next year to avoid missing active nests and locate pairs that may have formed or moved since the previous breeding season.

Incubation Behavior

Both male and female eagles shared in the responsibilities of incubating eggs and incubation behavior (e.g. length of bouts) appears to be consistent throughout the natural incubation period

(Keister and Anthony 1983). Our data contradict reports that female eagles incubate a greater percentage of the time than males (Gittens 1968); within a territory, the time spent incubating eggs did not differ significantly between adults, except for the West End birds.

Chick-Rearing and Fledgling Behavior

Stalmaster (1987, p.61) reported that during the month following hatching of the chick, adult males were primarily responsible for providing prey, while females were primarily responsible for brooding the chick. We found this to be true at all nests we observed.

This year's data also support our previous findings (Phillips and Garcelon 1995, 1996, Sharpe and Garcelon 1998, 1999, 2000) that nestlings begin standing and eating independently more frequently starting at approximately 45-50 days of age. Eagles appear to spend a large portion of time sleeping or resting when < 50 days old, then gradually become more active and participate in more energetically demanding behaviors as they approach fledging.

Prey Deliveries

The data collected in this study support the conclusion by Garcelon et al. (1997a,b) that bald eagles on Catalina Island exploit a wide variety of available foods. As has been found in other studies (Brown et al. 1991, Kozie and Anderson 1991, Todd et al. 1982), fish and birds comprised the majority of the bald eagle diet. Fish are the most important component of the diet of chicks on the nest, comprising greater than 87% of deliveries to the nests. The prey delivery rates at the four active nests this season indicate that prey items are brought to the nest an average of about 1-5 times per day (assuming a 12-hour active period).

Additional Eagle Sightings

We also are finding that bald eagles released in previous years are continuing to return to Catalina Island after having been seen on the mainland. Therefore, even though many of the young birds leave the island their first year this does not mean that they are being lost from the breeding population on Catalina Island.

CONCLUSIONS

Efforts to maintain the reintroduced population of bald eagles on Catalina Island were successful in 2002, as six eagles fledged from nests.

Collection and analysis of eagle eggs and other tissues should continue in order to provide accurate baseline data from which to compare changes that may occur when action to alleviate the contaminant burden in the sediments is undertaken. Because bald eagles are at the top of the food chain, they are one of the best species for monitoring the influence of organochlorine contaminants on the marine ecosystem.

Results from our study of nesting behavior do not indicate aberrant behavior associated with exposure to organochlorine contaminants; however, limited comparable data is available for wild

eagles that have not been exposed to contaminants. Study of additional nests on Catalina Island during future years may provide data to detect less apparent trends and increase power of statistical tests used to make comparisons between nests. Additionally, second generation effects of exposure to DDE may become apparent as juveniles produced by the nesting adults continue to return to Catalina Island to breed.

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Appendix I

ADULT BEHAVIORS TO BE RECORDED DURING SCAN SAMPLING

POSTURES

Standing (ST): Bird is upright on one or both of its feet on any substrate.

Sitting (SI): Bird is resting its weight on its tarsometatarsus (not its feet) and does not have its sternum touching the nest substrate.

Lying (L): Bird is prone on the nest with its sternum touching the nest substrate.

Flying (F): Feet of bird are not touching any substrate (flapping or hovering).

BEHAVIORS

Brooding (BR): Bird is sheltering chick under body or wing, and may be pulling nest material around its body.

Resting (R): Bird is lying in nest with its head resting on the substrate.

Eating (EA): The act of pulling at or swallowing food.

Feeding (FE): The act of preparing or giving food to a chick.

Preening (PR): Bird has its beak buried in its feathers or is running its beak along the shaft of a feather.

Nest

Maintenance (NM): Bird bringing nest material, or arranging nest material in the nest.

Walking (WA): Moving around the nest either in the standing or sitting postures.

Vocalizing (V): Head back, and appearing to vocalize.

Out of view (O): Bird is either facing away from camera and behavior is unknown, or bird is blocked from view by the nest or another bird.

Alert (A): Bird is attentively looking around or in a particular direction.

Non-Descript (N): Behavior belongs to no definite class (e.g., non-alert scanning, watching chick).

Appendix I (continued)

CHICK BEHAVIORS TO BE RECORDED DURING INTERVAL SAMPLING

POSTURES

Standing (ST): Bird is upright on one or both of its feet on any substrate.

Sitting (SI): Bird is resting its weight on its tarsometatarsus (not its feet) and does not have its sternum touching the nest substrate.

Lying (L): Bird is prone on the nest with its sternum touching the nest substrate.

Flying (F): Feet of bird are not touching any substrate (flapping or hovering).

Out of view (O): Bird is blocked from view by adult.

BEHAVIORS

Resting (R): Bird is lying in nest with its head resting on the substrate.

Eating (EA): The act of pulling at or swallowing food without help from an adult.

Feeding (FE): Act of taking food from the adult or swallowing food offered by the adult.

Preening (PR): Bird has its beak buried in its feathers or is running its beak along the shaft of a feather.

Playing (PL): Toying with nest material, feathers, or food.

Wing

Exercising (WE): Flapping both wings while the feet are in contact with the nest substrate.

Walking (WA): Moving around the nest either in the standing or sitting postures.

Wing-flap/Jump (J): Flapping wings and jumping from one part of the nest to another.

Wing Stretch (WS): Extending one wing or a wing and a leg.

Wings Out (WO): Extending both wings out, usually precedes a wing-flap/jump or flying.

Out-of-view (O): Bird is blocked from view by adult.

Non-Descript (N): Behavior belongs to no definite class (e.g., non-alert scanning, watching adult).

Appendix II

Specimens collected from bald eagles on Catalina Island, CA for analyses in 2002.

Tissue Type	Collection Location	Description
Red and White Blood Cells	Twin Rocks Nest	2.0 cc from 8-week old eaglet (K-21)
Whole Blood	Twin Rocks Nest	5.0 cc from 8-week old eaglet (K-21)
Plasma	Twin Rocks Nest	2.0 cc from 8-week old eaglet (K-21)
Red and White Blood Cells	West End Nest	2.0 cc from 8-week old eaglet (K-26)
Whole Blood	West End Nest	5.0 cc from 8-week old eaglet (K-26)
Plasma	West End Nest	3.0 cc from 8-week old eaglet (K-26)
Red and White Blood Cells	West End Nest	2.0 cc from 11-week old eaglet (K-27)
Whole Blood	West End Nest	5.0 cc from 11-week old eaglet (K-27)
Plasma	West End Nest	3.0 cc from 11-week old eaglet (K-27)
Red and White Blood Cells	Pinnacle Rock Nest	2.0 cc from 8-week old eaglet (K-22)
Whole Blood	Pinnacle Rock Nest	5.0 cc from 8-week old eaglet (K-22)
Plasma	Pinnacle Rock Nest	3.0 cc from 8-week old eaglet (K-22)
Whole Blood	Pinnacle Rock Nest	2.0 cc from 8-week old eaglet (K-23)
Red and White Blood Cells	Seal Rocks Nest	2.0 cc from 11-week old eaglet (K-28)
Whole Blood	Seal Rocks Nest	5.5 cc from 11-week old eaglet (K-28)
Plasma	Seal Rocks Nest	3.5 cc from 11-week old eaglet (K-28)
Egg Contents ^a	Twin Rocks Nest	Sample ID # GTRBEE50
Egg Contents ^a	Twin Rocks Nest	Sample ID # GTRBEE51
Egg Contents ^a	West End Nest	Sample ID # GWEBEE52
Egg Contents ^a	West End Nest	Sample ID # GWEBEE53
Egg Contents ^a	Pinnacle Rock Nest	Sample ID # GPRBEE54
Egg Contents ^a	Seal Rocks Nest	Sample ID # GSRBEE55
Egg Shells from All 7 Eggs ^a	All Territories	NA
Major Organs from 3.5 mo old Chick	Twin Rocks Nest	Collected from chick that hatched, but was later euthanized because of injury

^a Collected by staff at San Francisco Zoo. Egg shells were rinsed in water, air dried, and stored in aluminum foil. Shell contents were placed directly into a chemically clean jar, sealed with an evidence label, and frozen.